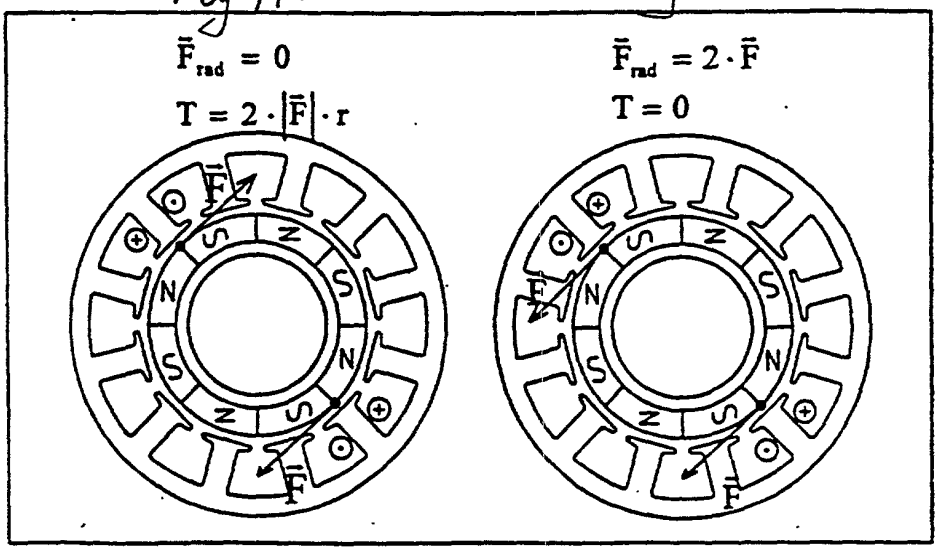
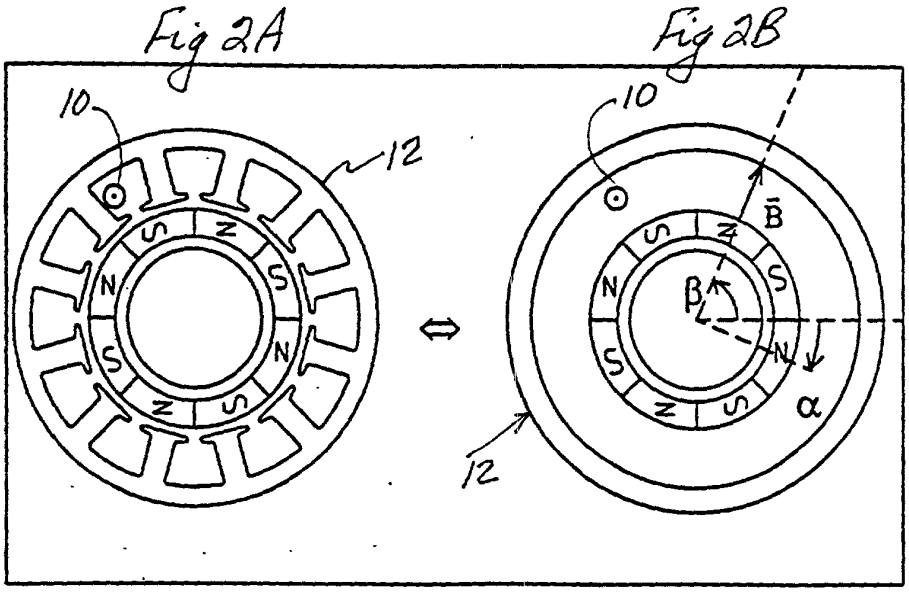
Fig 1A

Fig 1B



a: 2 coils generating torque *b: 2 coils generating radial force*

Fig. A.1



a: conductor placed in one slot *b: assumption that conductor is placed in the airgap*

Fig. A.3

Fig. 3A

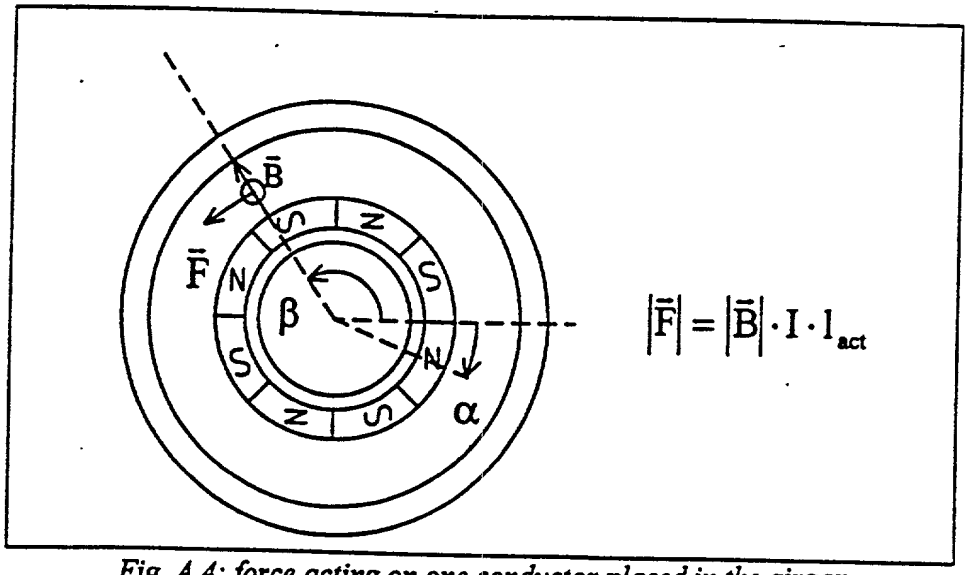


Fig. A.4: force acting on one conductor placed in the airgap

Fig. 3B

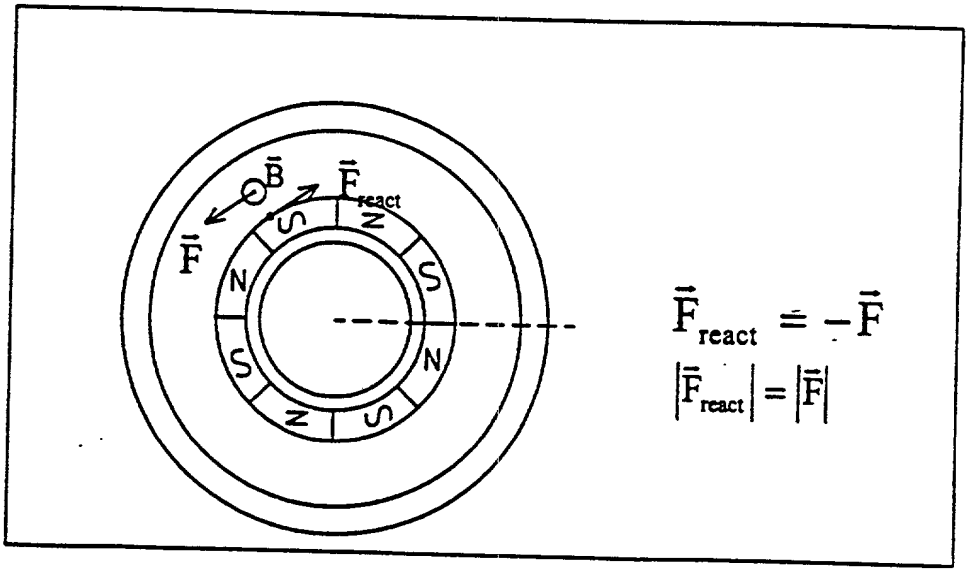


Fig. A.5: action and reaction rule, force acting on the magnet due to current flowing through the conductor placed in the airgap.

Fig. 4

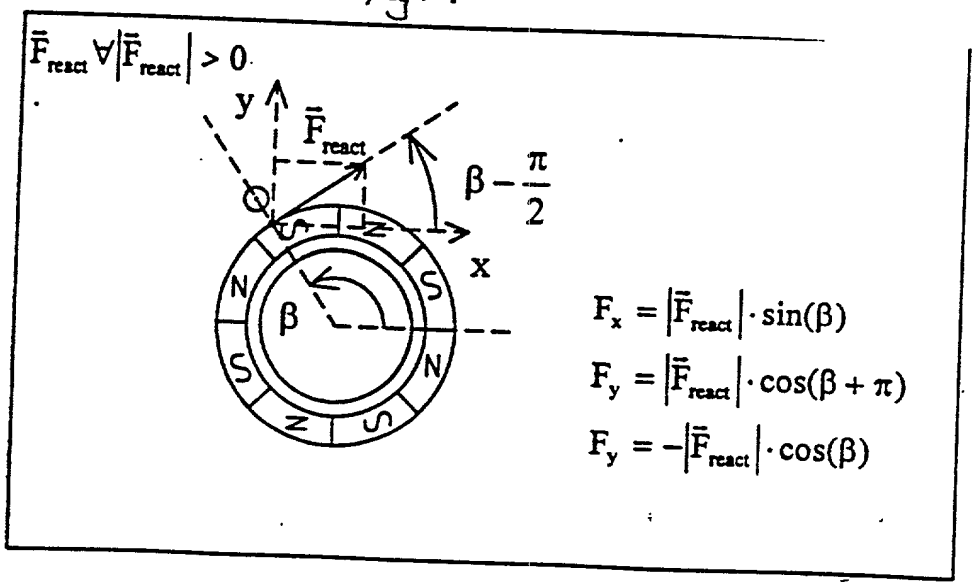


Fig. A.6: projection of the force on the x and y axis.

Fig. 5

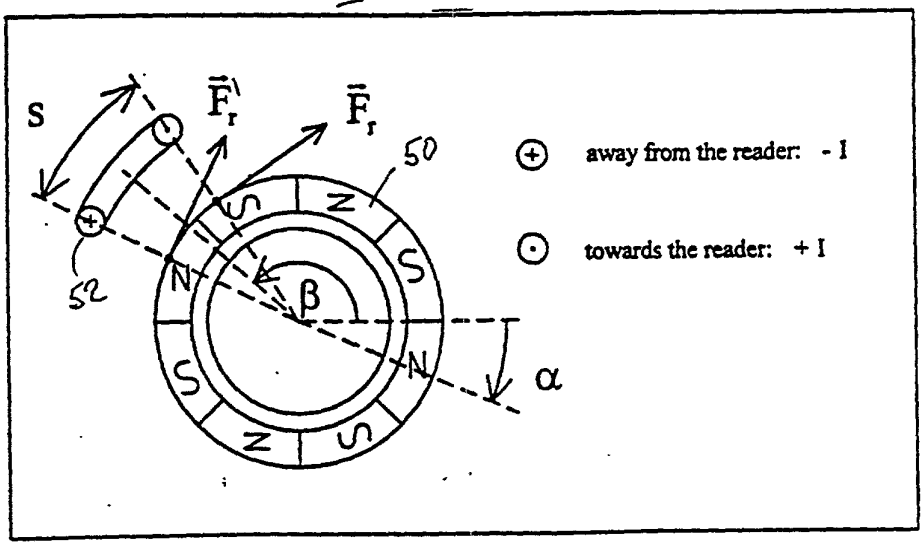


Fig. A.7: 2 forces acting on the magnet when one coil is placed in the airgap.

Fig 6A

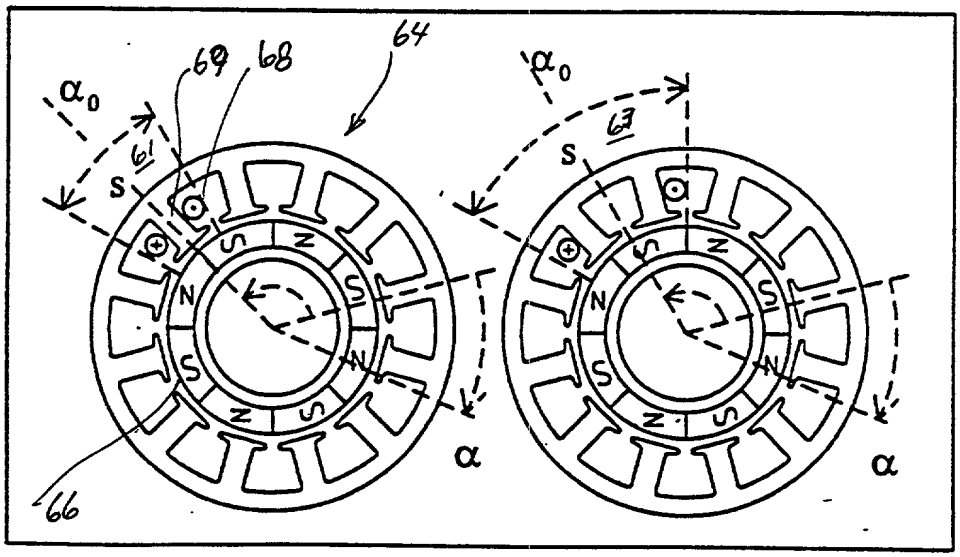


Fig 6B

~~a: coil opening of 1 slot~~ ~~b: coil opening of 2 slots~~

~~Fig. A.8~~

Fig 7

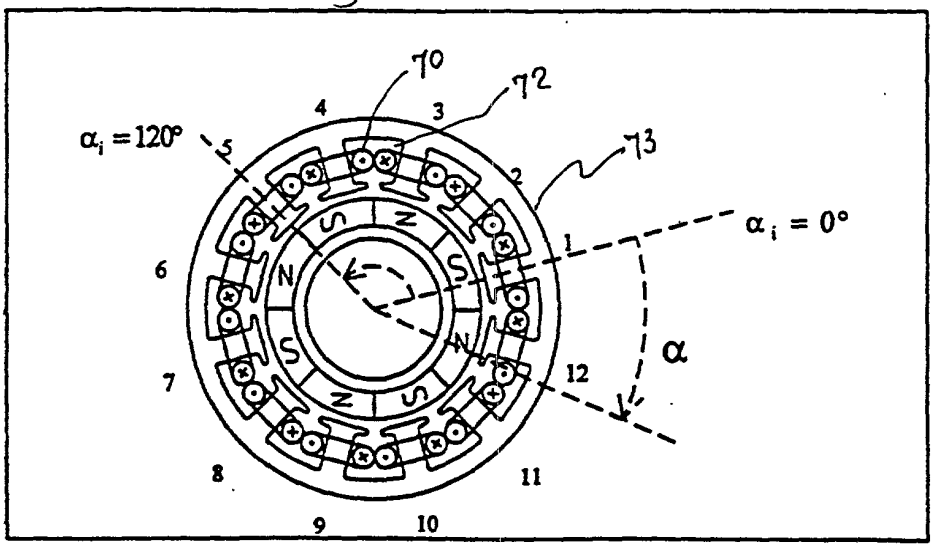


Fig. A.10: 12 concentric coils placed in the 12 slots of the motor.

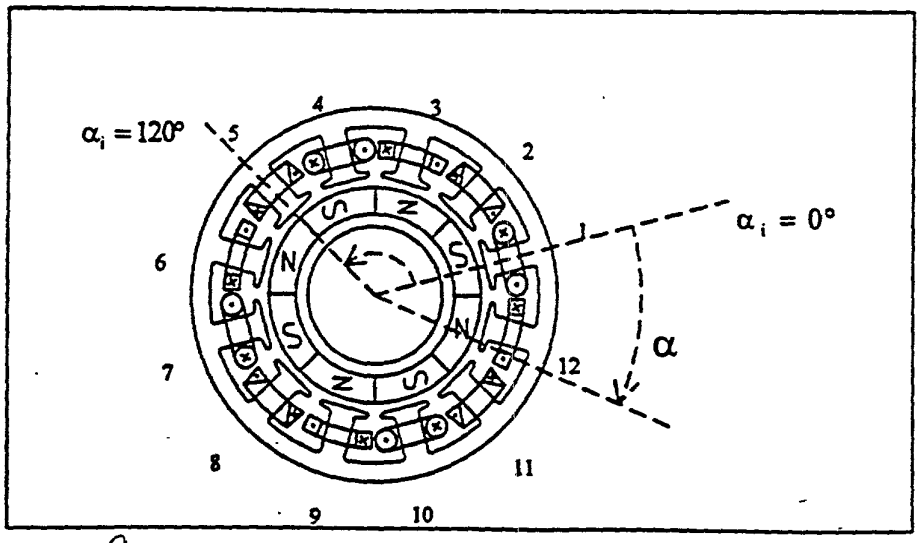


Fig. ~~A.12~~: 3 phase winding generating torque for a 8 poles 12 slots motor

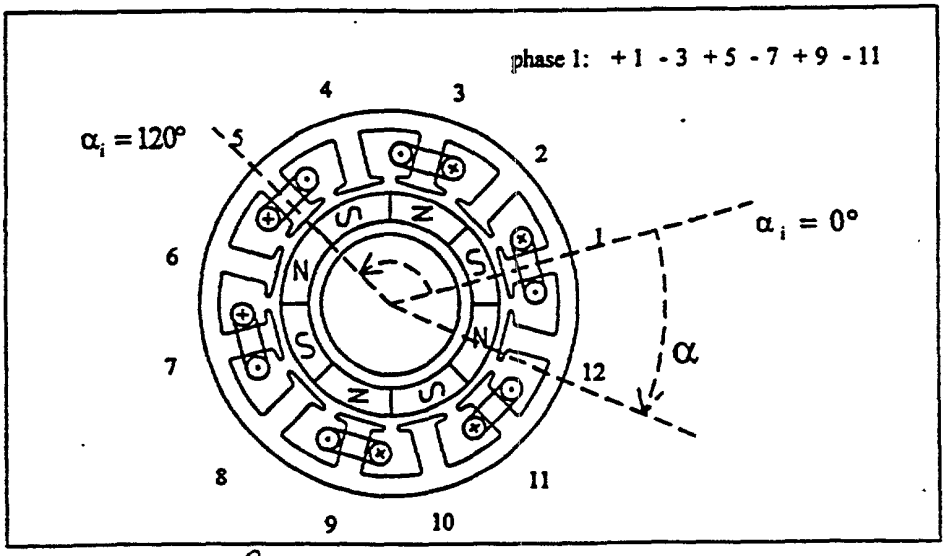


Fig. ~~A.14~~: one phase of 6 coils generating a radial force.

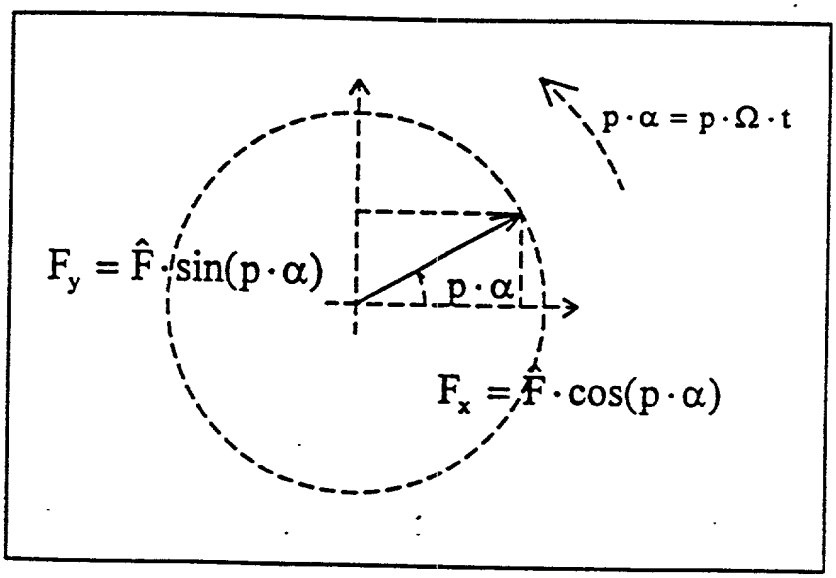


Fig. ~~A.15~~: one rotating radial force.

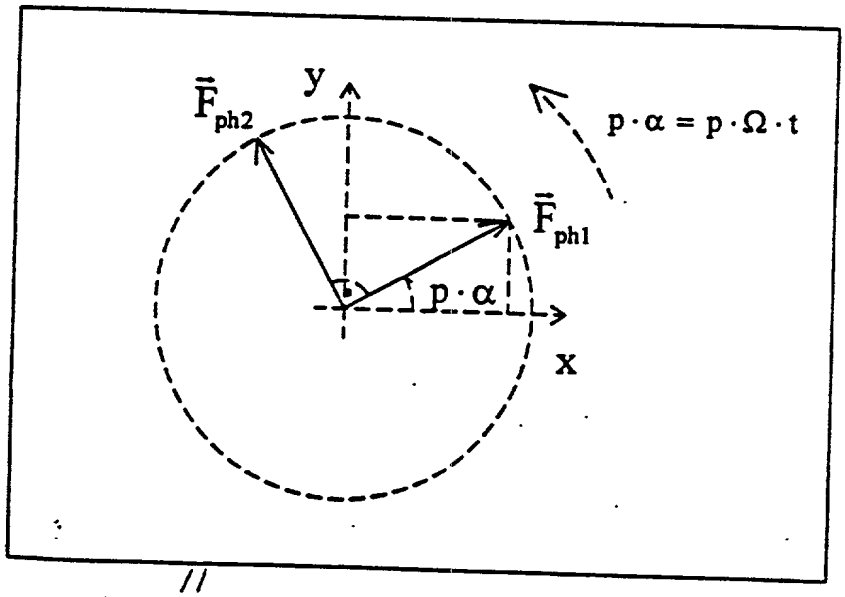
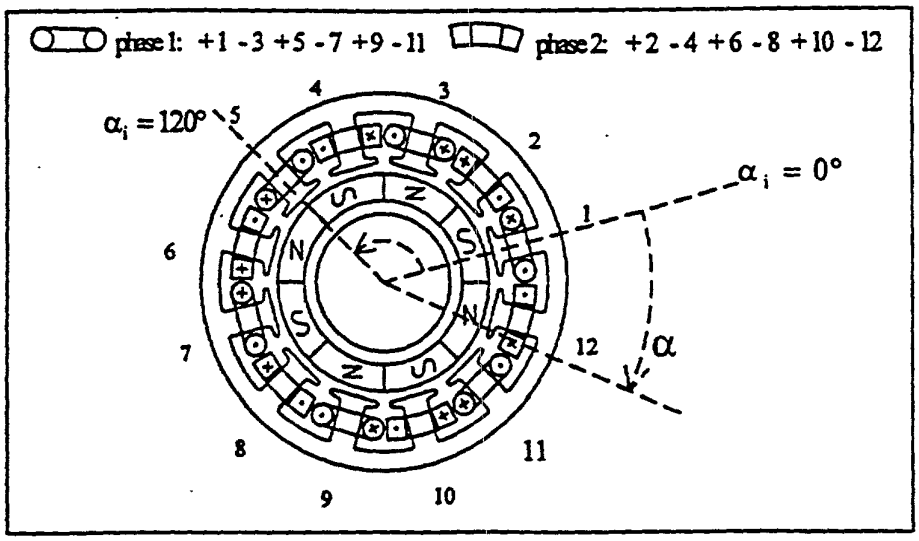
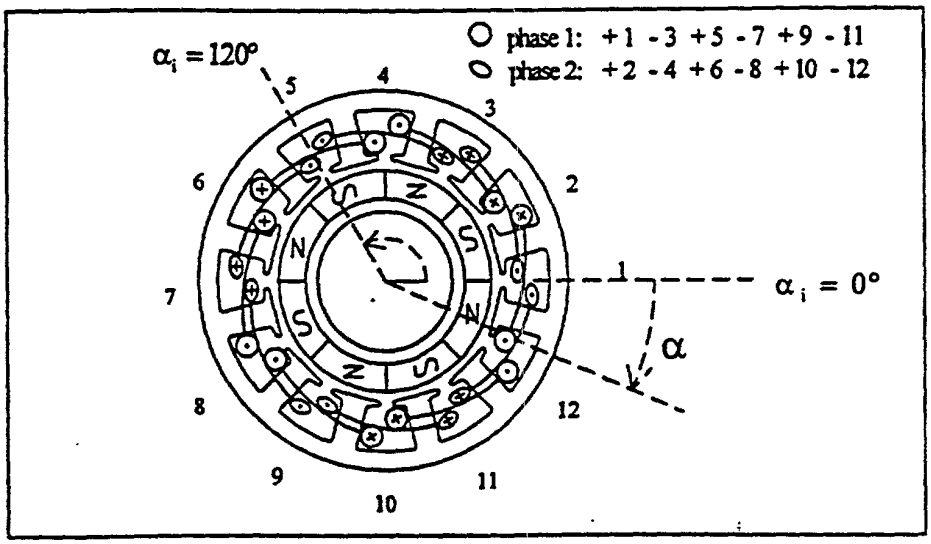


Fig. ~~4.16~~: 2 rotating radial forces in quadrature.



12

Fig. ~~A.18~~: 2 phase winding generating 2 radial forces in quadrature, coil-opening of 1 slot.

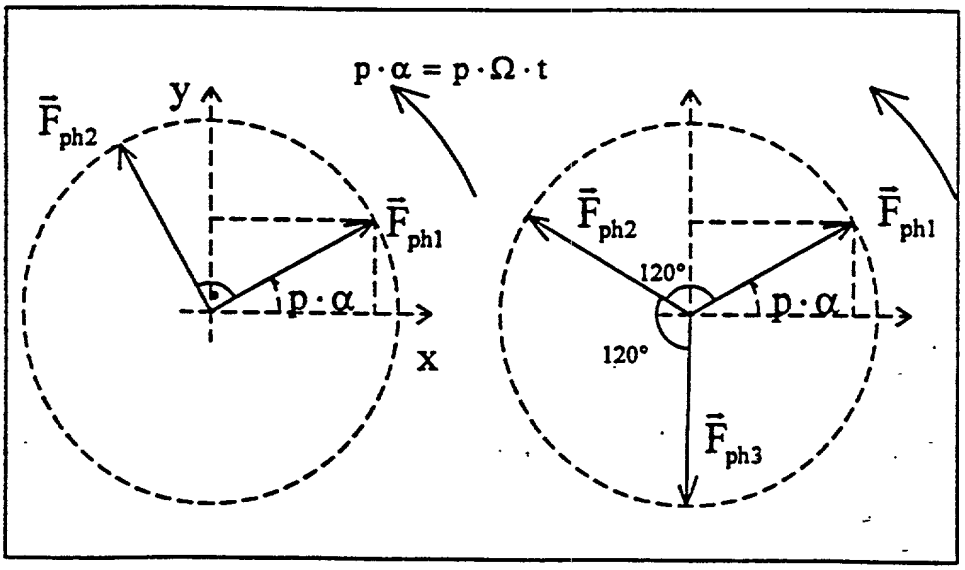


13

Fig. 4.19: 2 phase winding generating 2 radial forces in quadrature, coil opening of 2 slots.

FIG 14A

FIG 14B



a: 2 rotating forces in quadrature. *b: 3 rotating forces separated by* 120°.

Fig. ~~A 25~~

Fig. 15

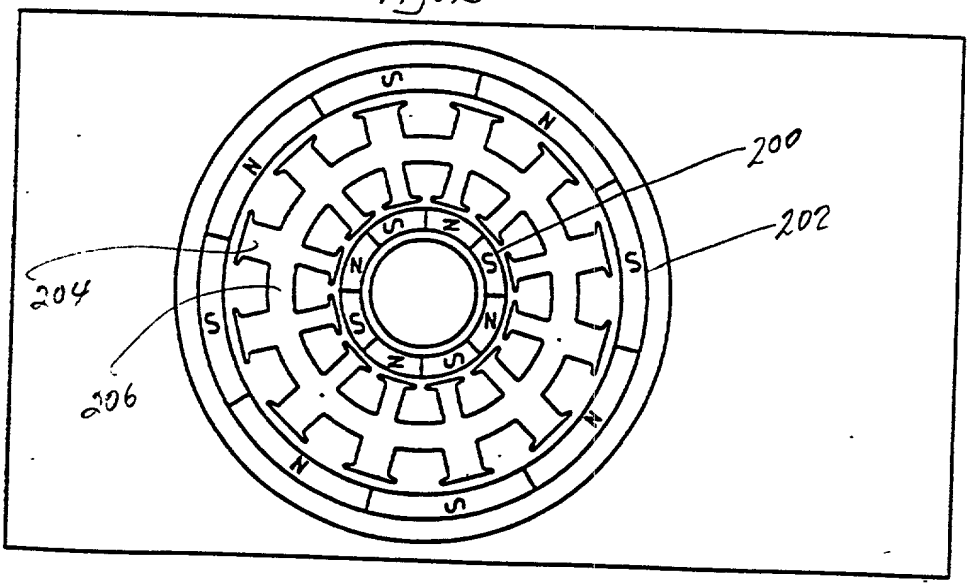


Fig. A.27: motor structure with 2 magnetic circuit.

Fig 16A

Fig. 16B

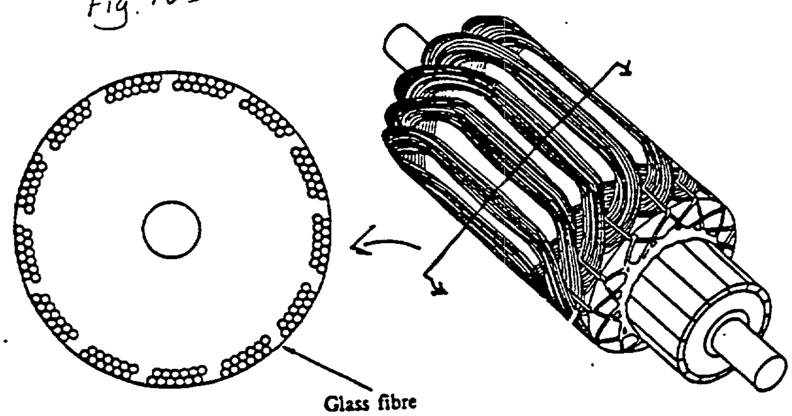
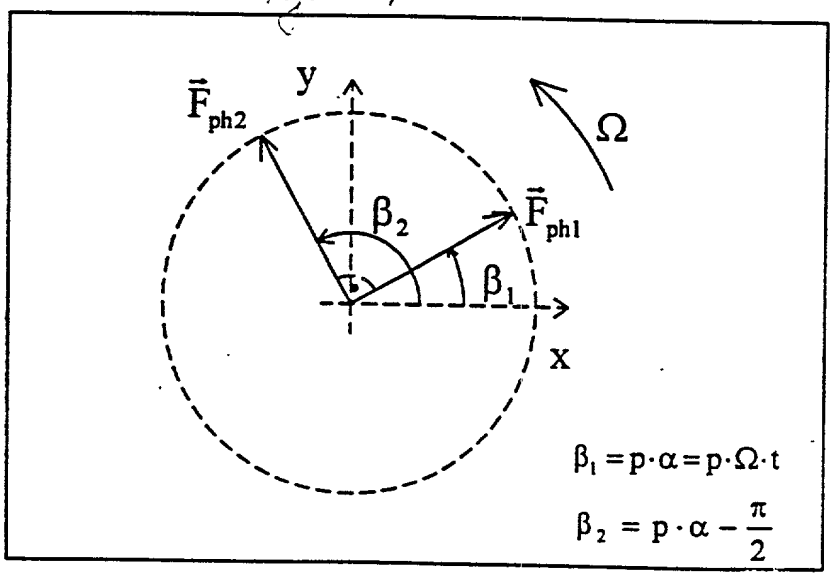


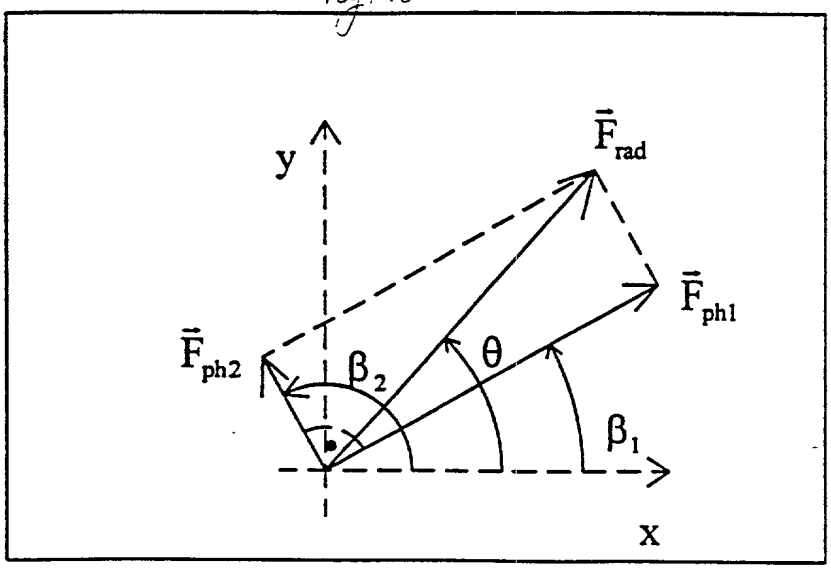
Fig. ~~A.28~~ 16: example of a slotless motor winding (cylinder placed in the airgap).

Fig. #17



~~Fig. A.34~~: 2 rotating radial forces in quadrature.

Fig. #18



~~Fig. A.35~~: projection of the radial force vector onto the vectors of the forces generated by phases 1 and 2.

Fig 19

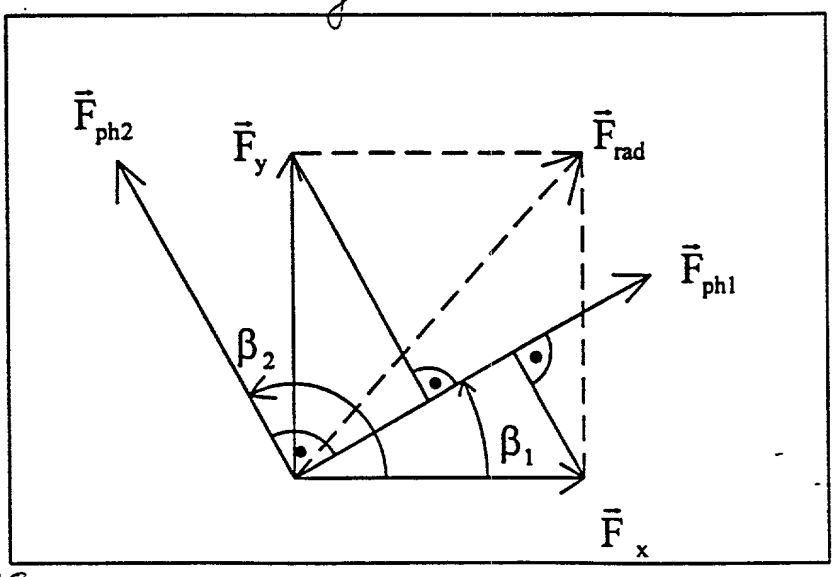
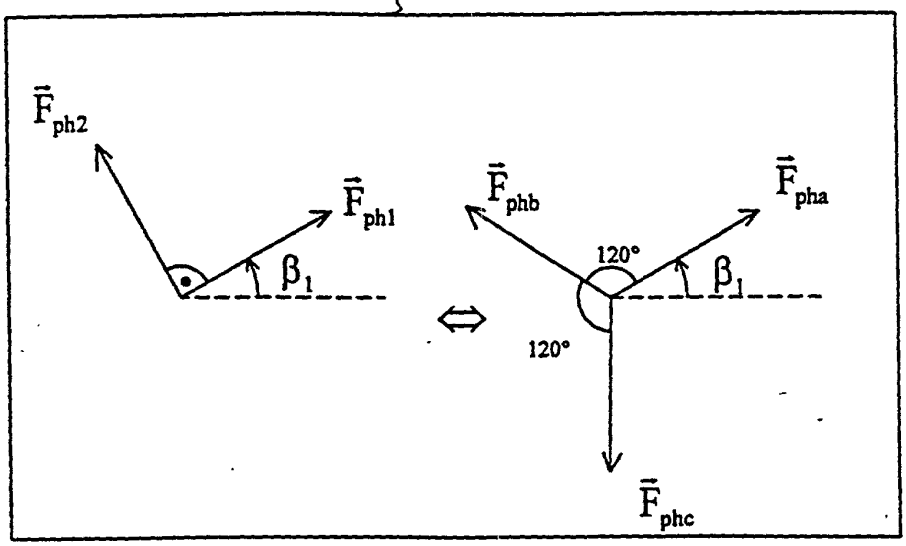


Fig. A36: projections of the x and y radial force component vectors onto the vector of the force generated by phase 1.

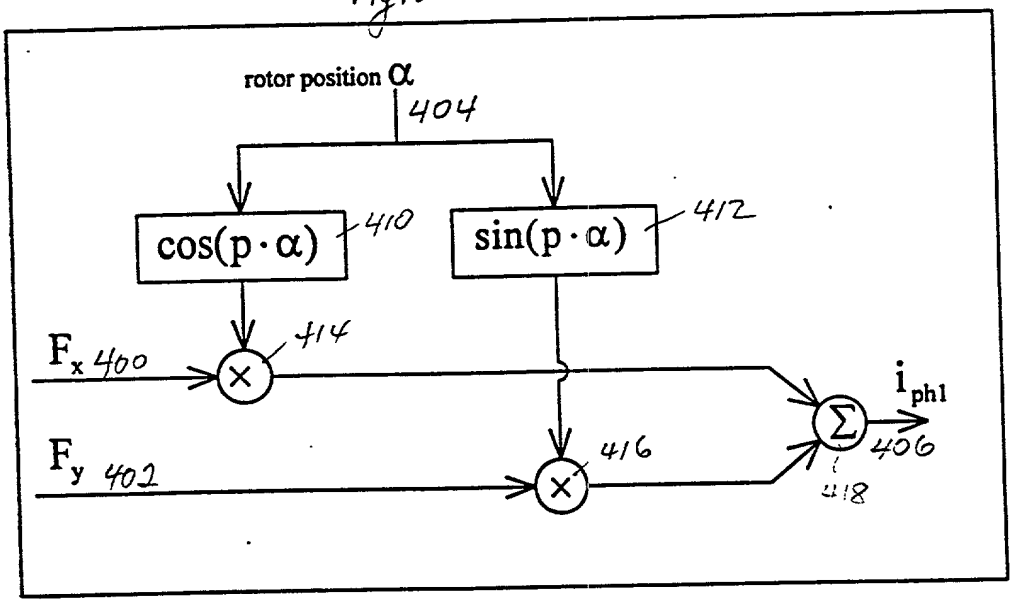
Fig. 20



19

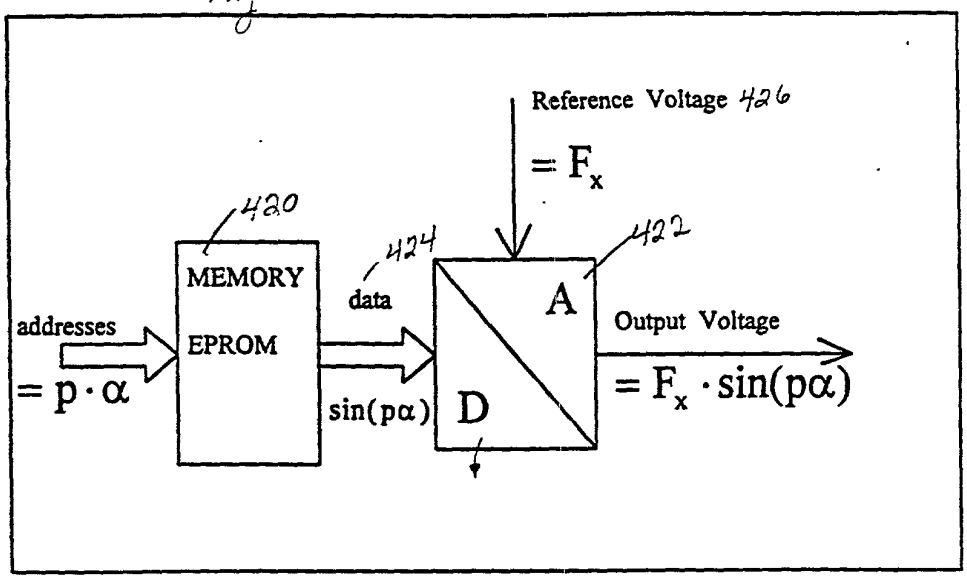
Fig. ~~4.37~~: relationship between a sum of 2 forces in quadrature and a sum of 3 forces which directions are separated by 120°.

Fig. 21



~~Fig. A.38~~: bloc diagram of the phase 1 current calculation (expression (a.59)).

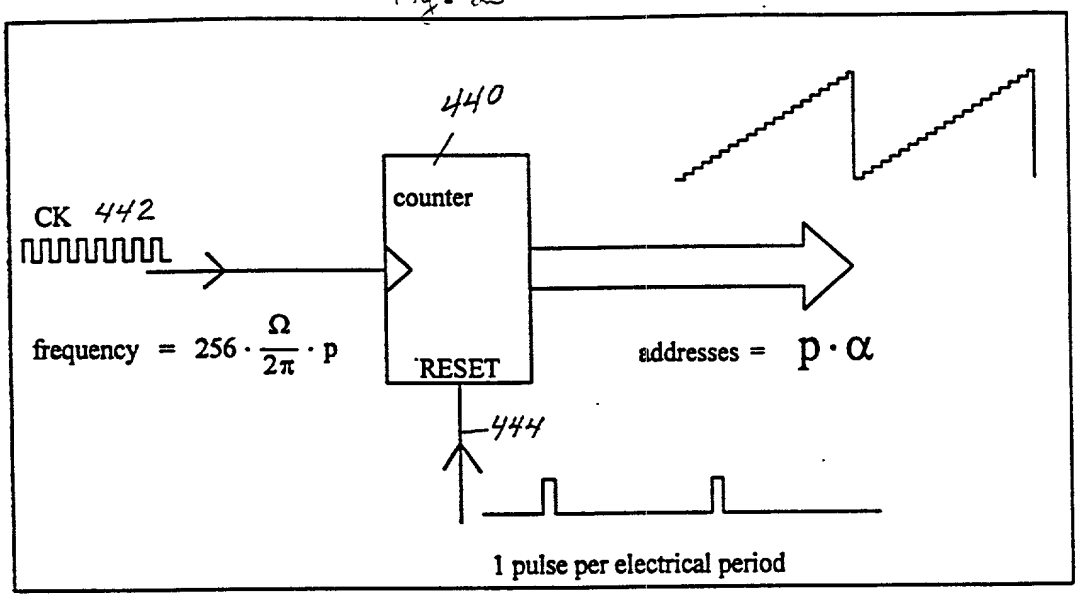
Fig 22



21

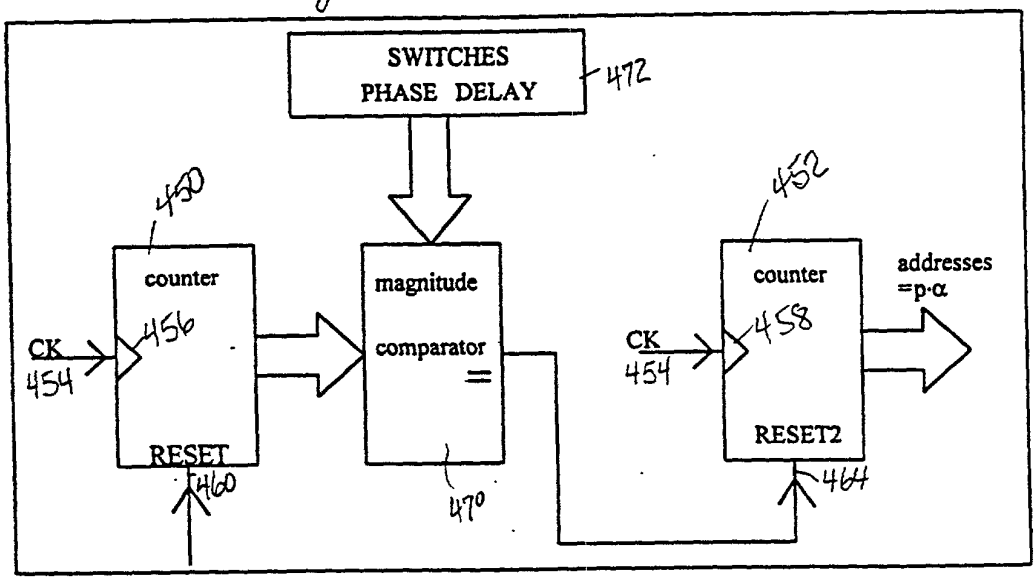
Fig. 239: electronic solution processing one trigonometric function and one multiplication.

Fig. 23



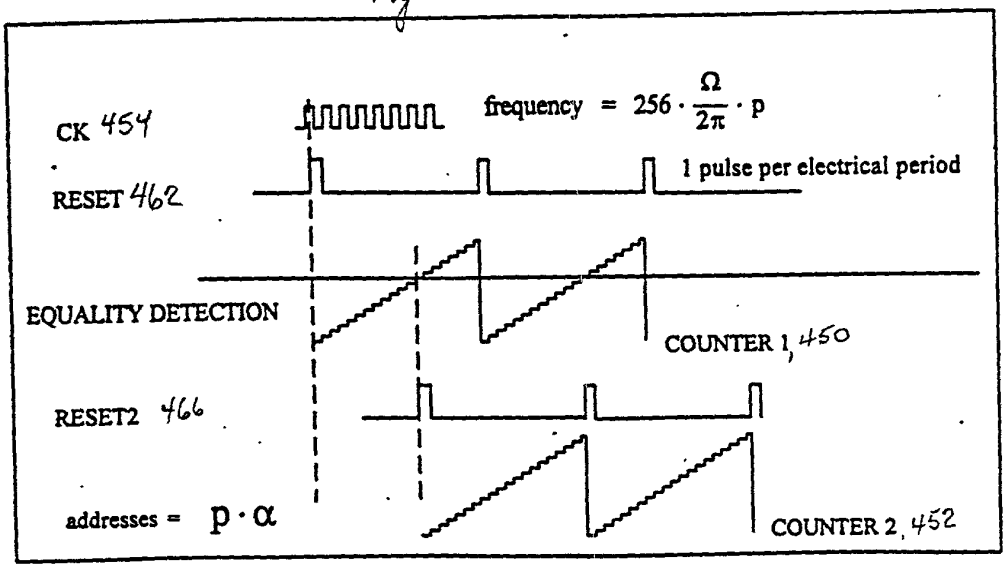
~~Fig. A 40~~: *electronic solution for generating the EPROM addresses as a function of the rotor position.*

Fig 24



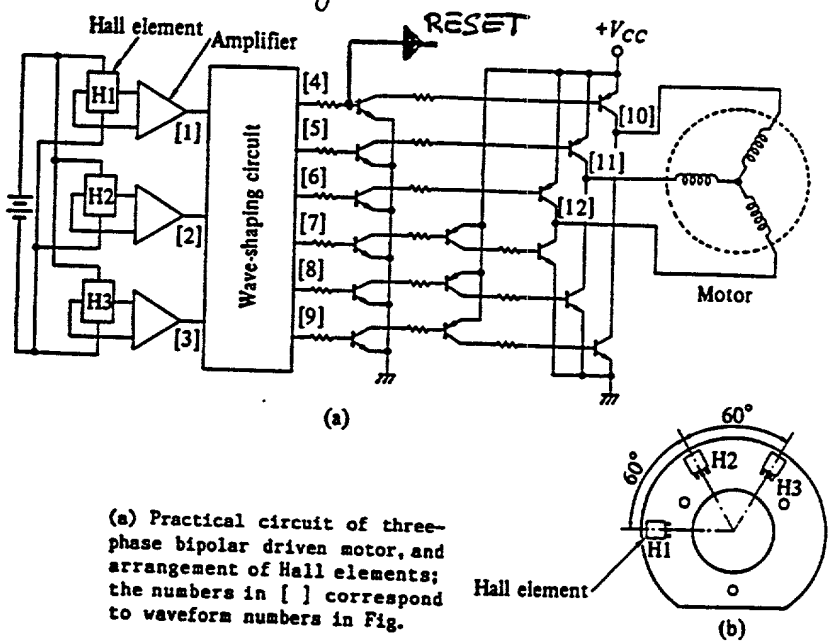
~~Fig. A.42:~~ electronic solution generating the EPROM addresses as a function of the rotor position, with phase delay adjustment ~~possibility~~

Fig 25



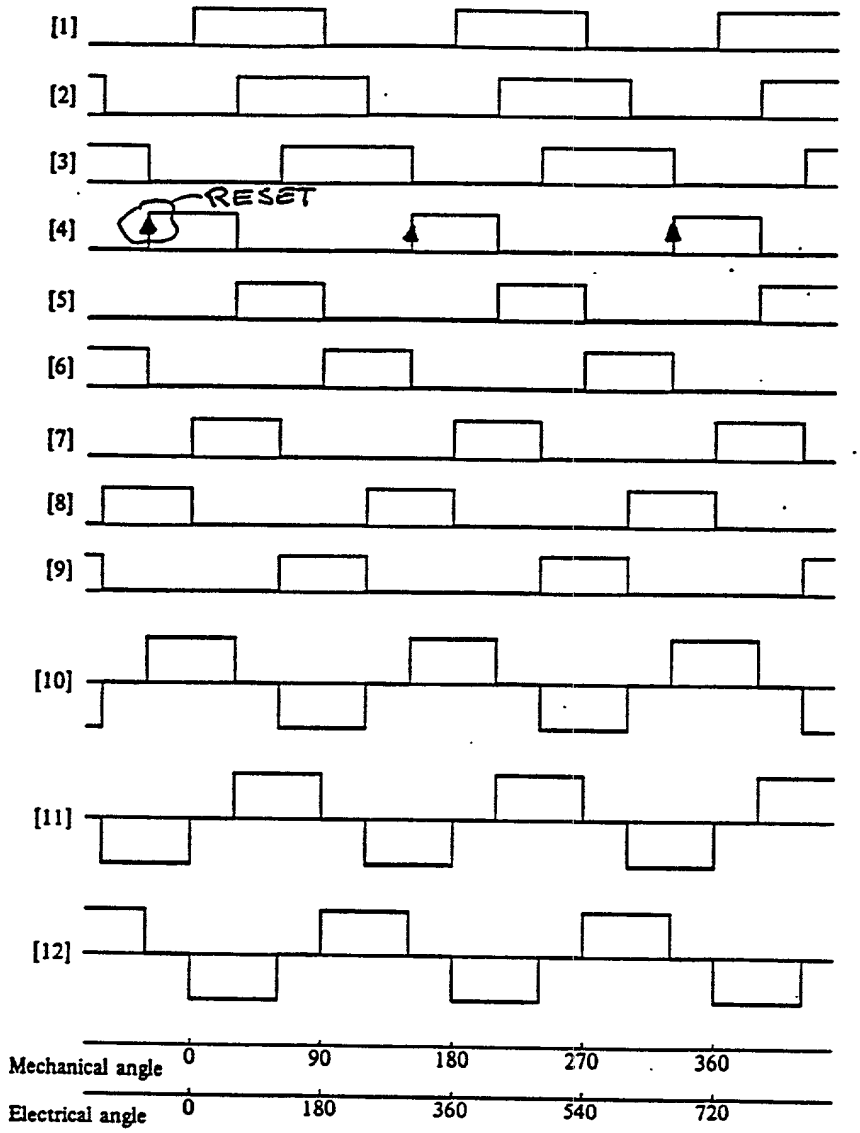
~~Fig. A.43:~~ Timing diagram corresponding to the electronic solution of Fig. A.42.

Fig 26



(a) Practical circuit of three-phase bipolar driven motor, and arrangement of Hall elements; the numbers in [ ] correspond to waveform numbers in Fig.

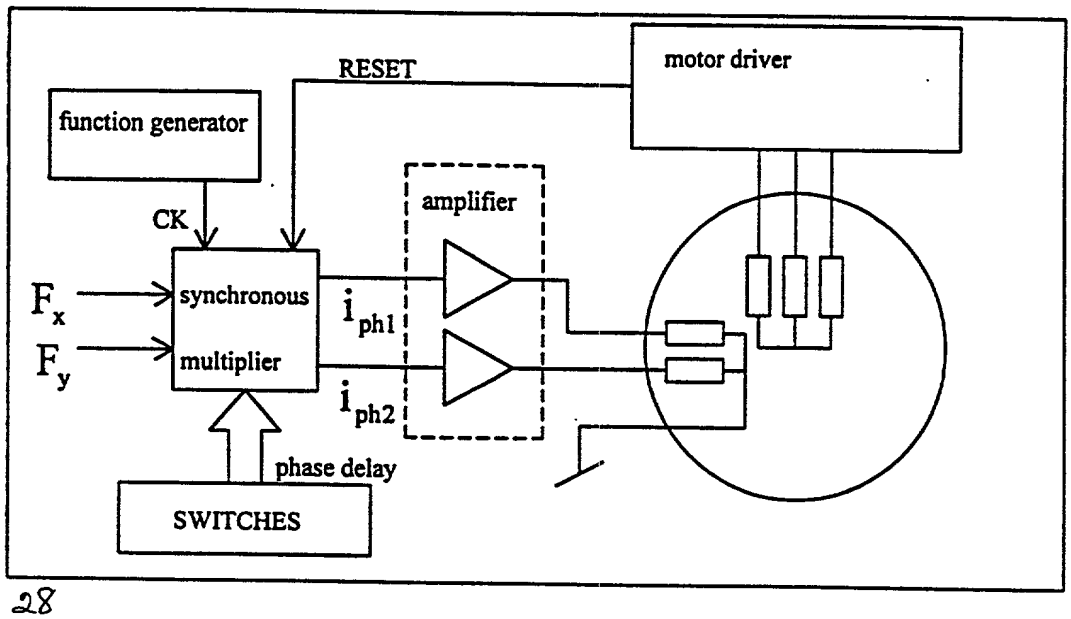
Fig. A.44: Using a transistor command signal of the motor driver to generate one pulse per electrical period.



Voltage waveforms at each part (see Fig. A.44(a)).

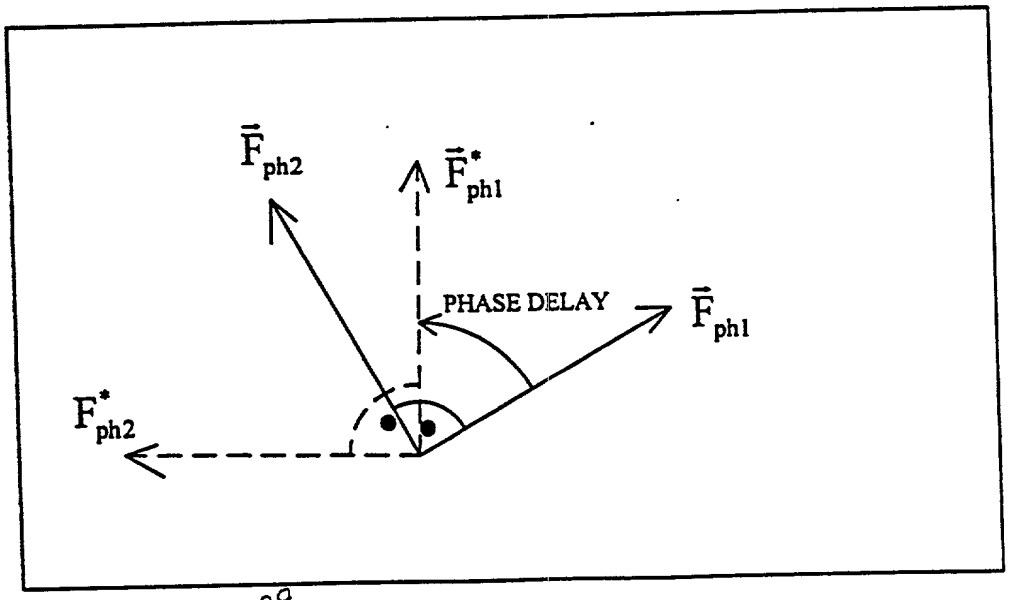
27

Fig. ~~A.45~~: Using a transistor command signal of the motor driver to generate one pulse per electrical period, timing diagram.



28

Fig. ~~A.46~~: final bloc diagram of the electronic supply of the 2 phase winding generating radial force .



29

Fig. ~~A.47~~: phase delay effect on the radial force direction.

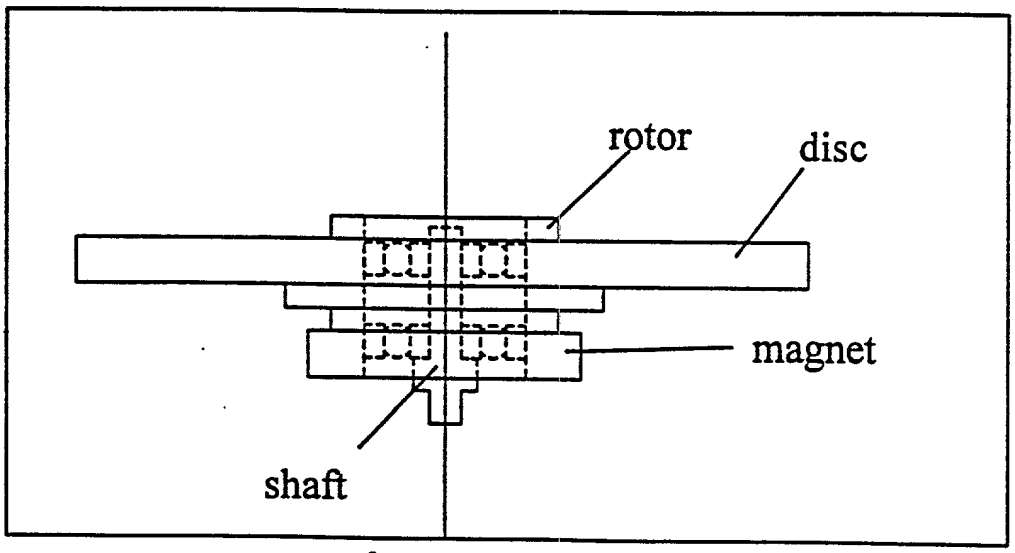
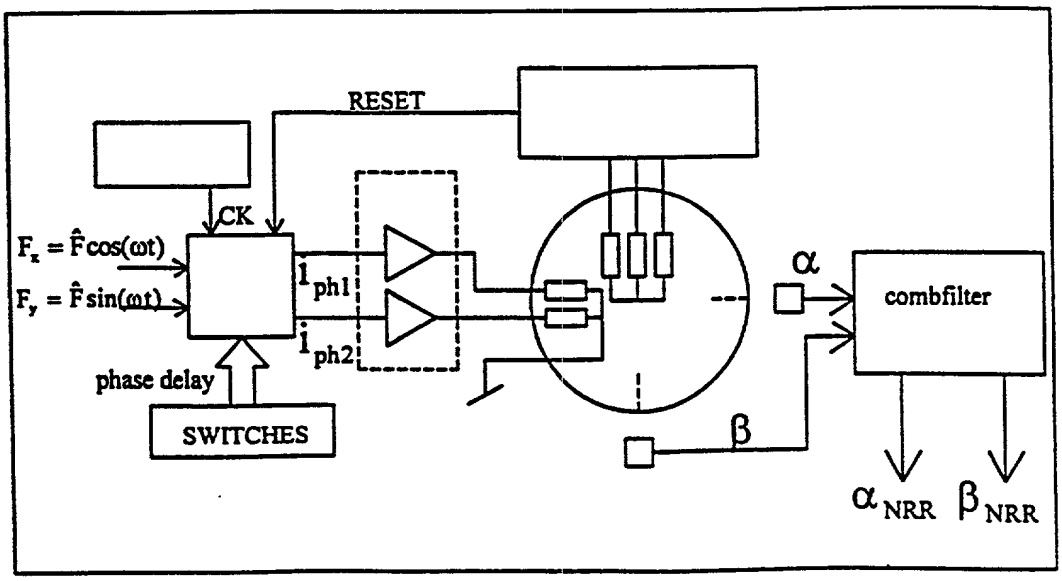
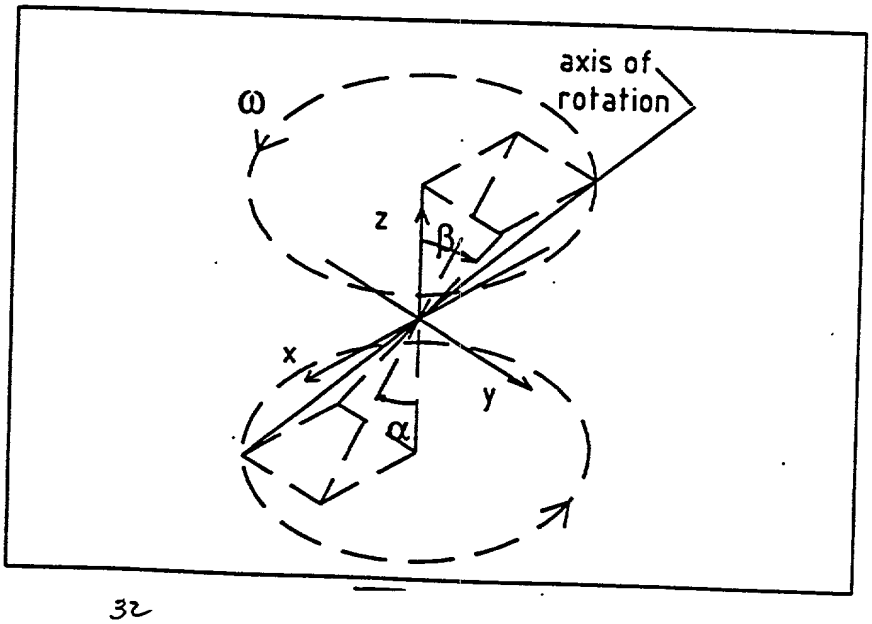


Fig. A.48: harddrive spindle motor.



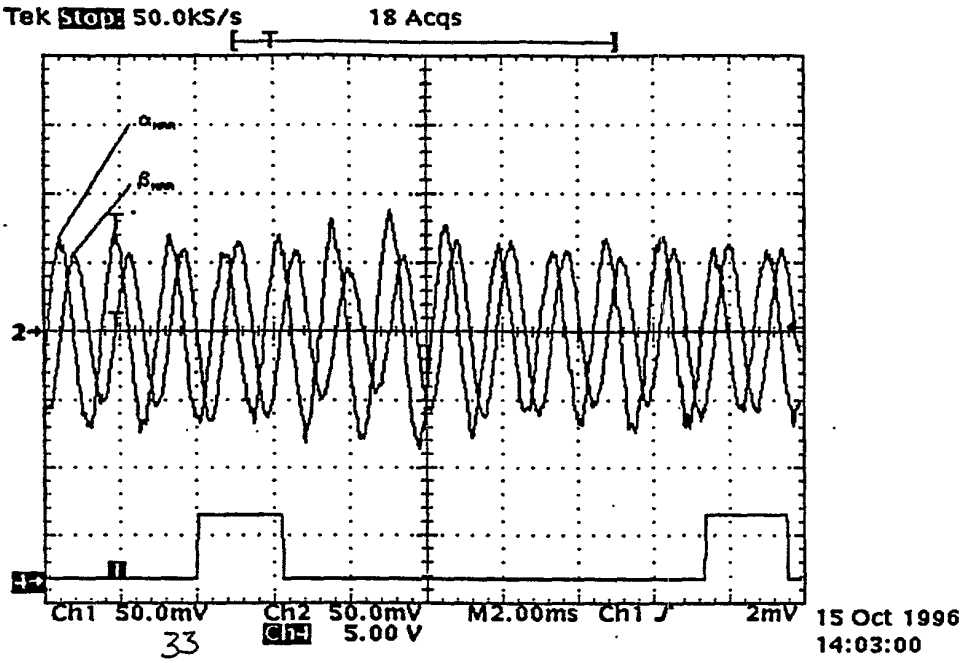
31

Fig. ~~A.49~~: measurement of the response to a rotating radial force excitation.



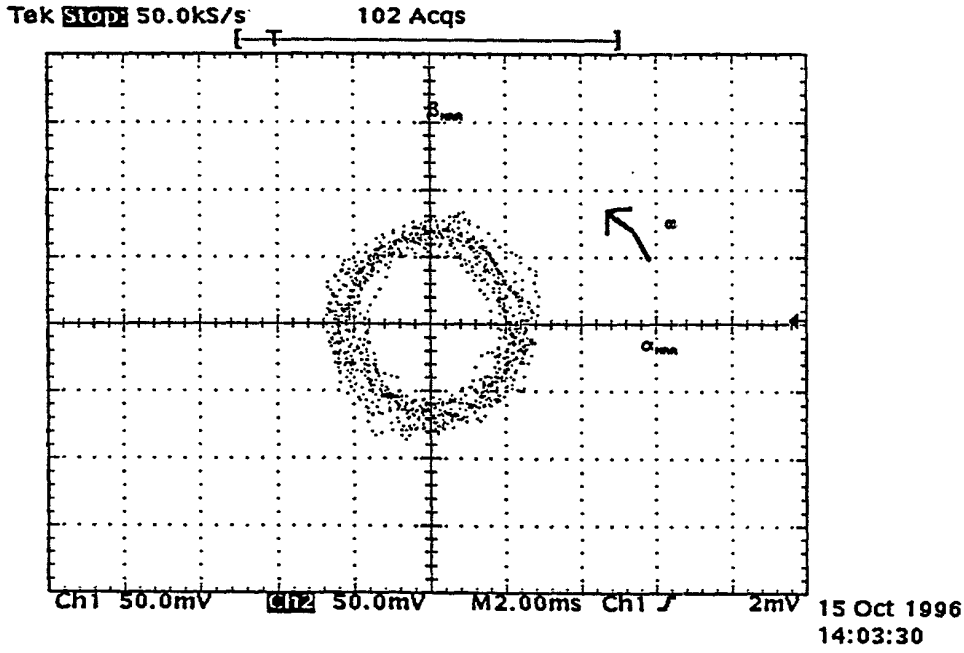
32

Fig. ~~A.50~~: definition of the rotational axis angular position



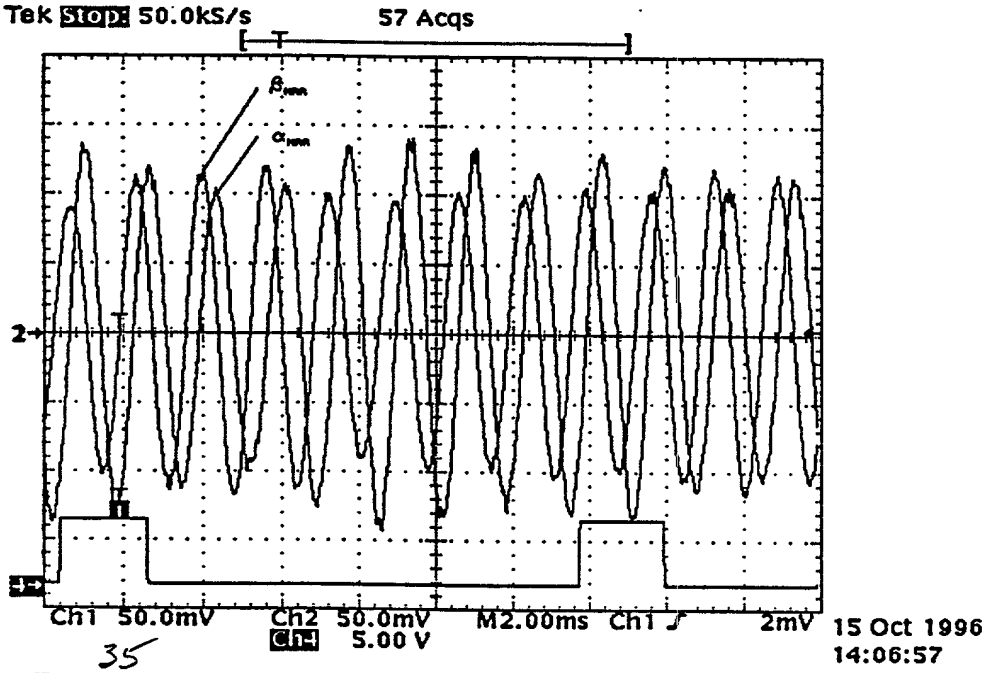
33

Fig. ~~A.51~~: excitation of the forward gyroscopic mode, measure of the NOR components of α and β, measure of a signal giving one pulse per revolution.



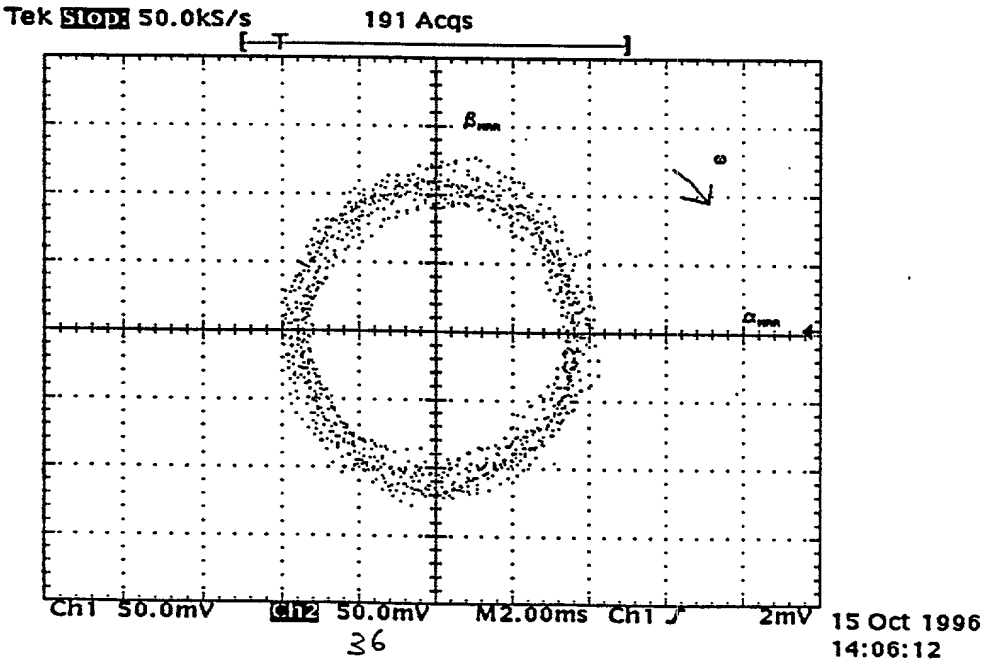
34

Fig. ~~A.52~~: excitation of the forward gyroscopic mode, Lissajou figure of the NRR components of α and β.



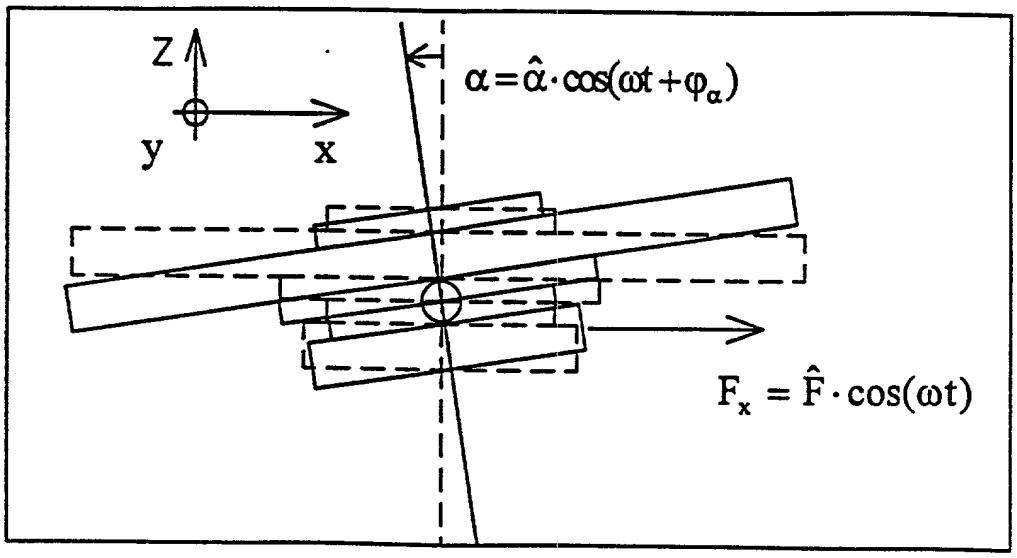
35

Fig. ~~A.53~~: excitation of the backward gyroscopic mode, measure of the NRR components of α and β, measure of a signal giving one pulse per revolution.



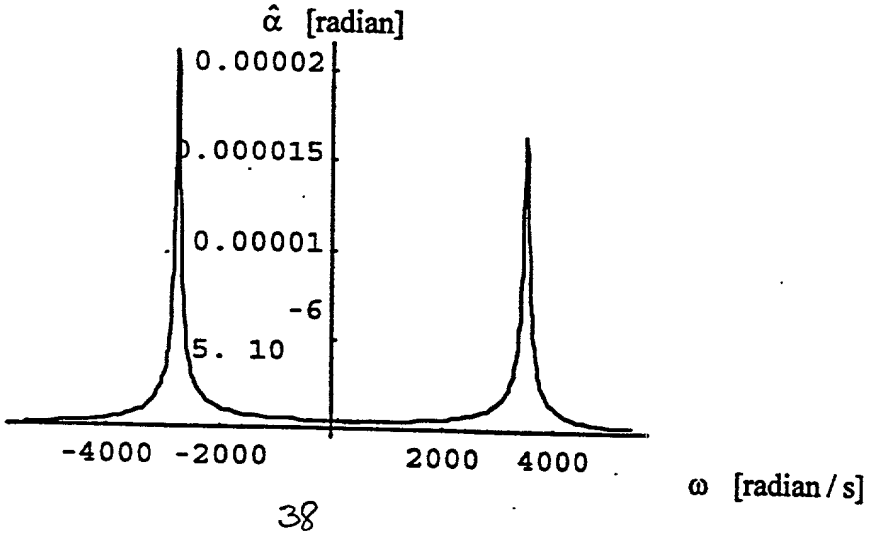
36

Fig. ~~A.54~~: excitation of the backward gyroscopic mode, Lissajou figure of the NRR components of α and β.



37

Fig. ~~A.55~~: rotor motion in plan xz.



38

Fig. ~~A.56~~: Bode plot of the α wave magnitude .

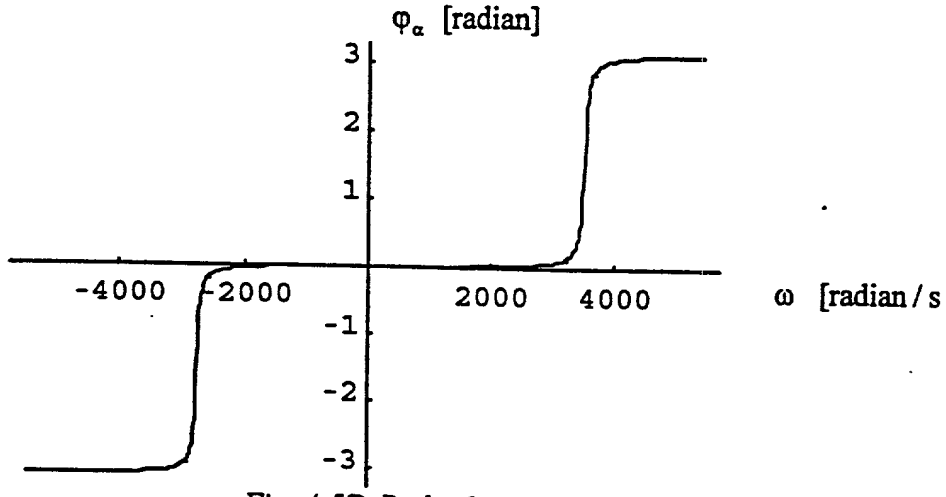
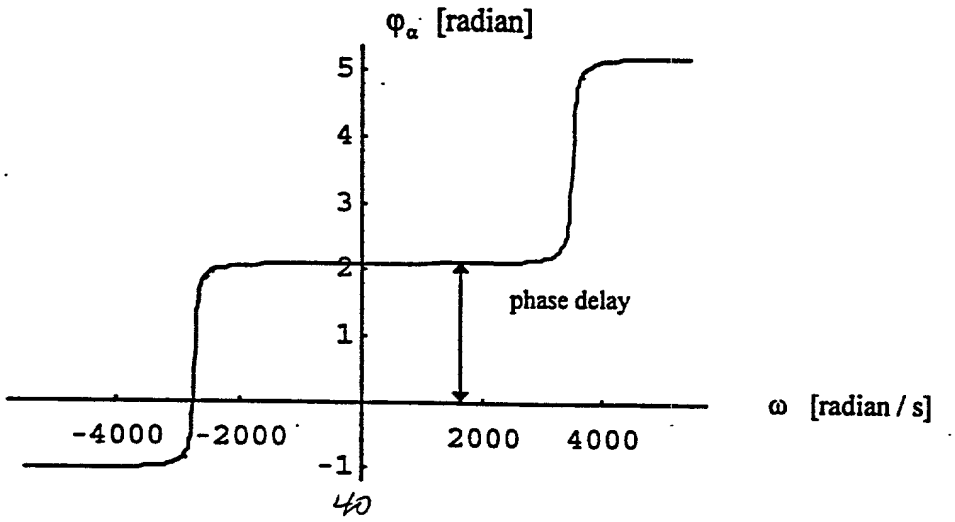


Fig. A.57: Bode plot of the α wave phase delay .



40

Fig. A.58: Bode plot of the α wave phase delay including the effect of the synchronous multiplier phase delay.

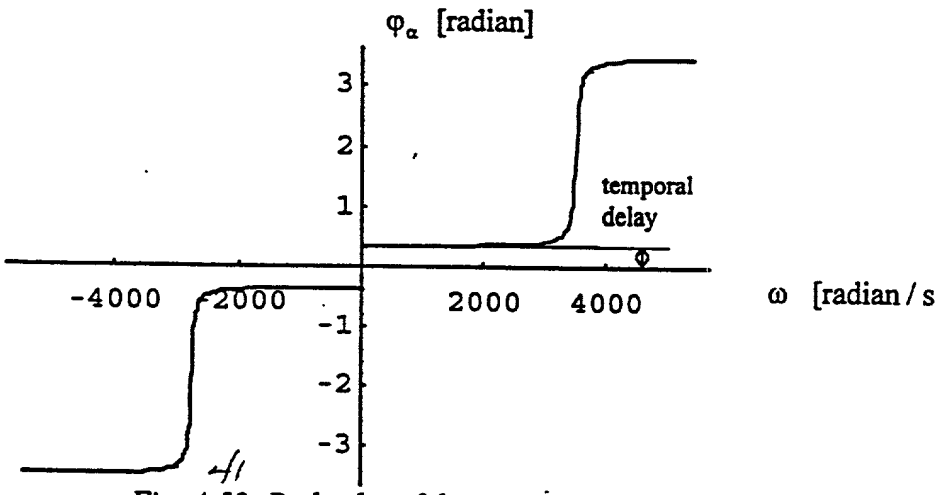
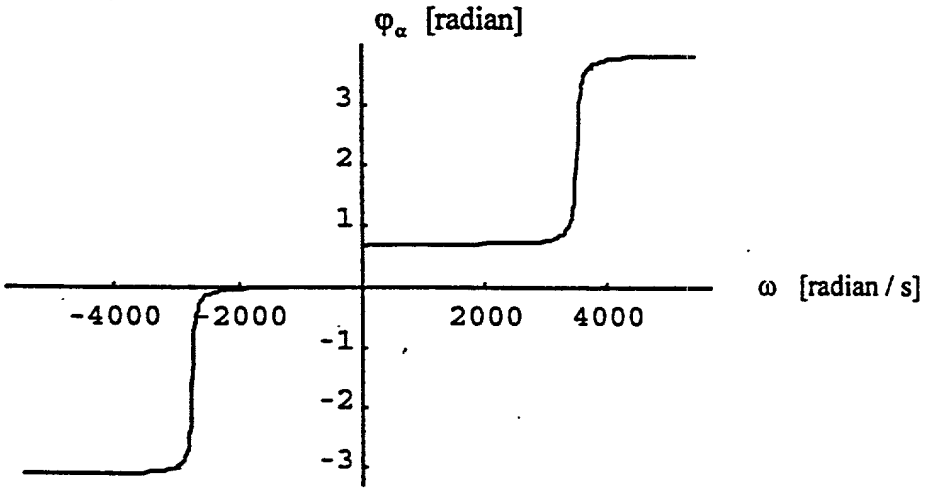


Fig. A.59: Bode plot of the α wave phase delay, including the temporal delay introduced by the current amplifiers and by the measure system.



42

Fig. ~~A 60~~: correction of the temporal delay of the backward gyroscopic mode with the synchronous multiplier phase delay.